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Article

Conceptualizing the Digital Sharing Economy in the Context of Sustainability

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Abstract: Human society is increasingly influencing the planet and its environmental systems. The existing environmental problems indicate that current production and consumption patterns are not sustainable. Despite the remarkable opportunities brought about by Information and Communication Technology (ICT) to improve the resource efficiency of production and consumption processes, it seems that the overall trend is still not heading towards sustainability. By promoting the utilization of available and underused resources, the ICT-enabled sharing economy has transformed, and even in some cases disrupted, the prevailing patterns of production and consumption, raising questions about opportunities and risks of shared consumption modes for sustainability. The present article attempts to conceptualize the sustainability implications of today's sharing economy. We begin with presenting a definition for the digital sharing economy that embraces the common features of its various forms. Based on our proposed definition, we discuss the theoretical and practical implications of the digital sharing economy as a use case of ICT. The analysis is deepened by applying the life-cycle/enabling/structural impacts model of ICT effects to this use case. As a result, we show the various positive and negative potentials of digital sharing for sustainability at different system levels. While it is too early to project well-founded scenarios to describe the sustainability status of digital sharing, the implications discussed in our work may help outlining future research and policies in this area.

Keywords: information and communication technology; ICT; digital sharing economy; platforms; sustainability; environment

1. Introduction

Sharing has been a common form of allocating and accessing resources in human societies. While sharing is as old as mankind, the 'sharing economy' is a phenomenon that advanced with the Internet [1] and came to the fore as part of the digital transition. The penetration of Information and Communication Technology (ICT) into everyday life pushed the narrow boundaries of conventional sharing activities and created scalable sharing economies. People are becoming increasingly interested in the shared use of goods instead of buying and owning them [1]. Cost savings, social benefits, and the potential convenience motivate consumers to participate in sharing [2,3]. These benefits have been enabled by digital technology that acts as a mediator to reduce the transaction costs and to increase seamless connectivity between providers who offer services and/or goods for sharing and those who intend to receive them.

Sharing needs information: In order to share a (tangible or intangible) resource within a group of people, the access to that resource must be coordinated—a process which requires information to be (as well) shared among these people. Although information is a sharable resource by itself, time and

place constraints to information sharing may have restricted the scope of traditional sharing economies. In today's sharing economies, information is shared online, a fact that brings unprecedented scalability to the sharing economy.

Before the advent of the digital sharing economy, businesses were the main providers of services and products in the formal economy. With the aid of real-time information on the available and requested resources in a system, people now experience new roles as providers of services/goods in their peer networks. In fact, peers can be either suppliers or consumers of resources, or both at the same time, a role that has been termed "prosumer" [4]. This quality describes the sharing economy as having reformed social bonds by reinforcing social connections to perform economic activities and by leveraging value from the social connection of strangers [5].

In recent years, there has been rapid growth in the use of digital sharing platforms by individuals and also companies in various sectors. The growth of digital sharing businesses has reached a level that has disrupted established industries around the world [6]. In some cases, the growth has been described explosive and spectacular, as with Airbnb and Uber [7,8], two popular platforms for peer-to-peer hospitality services and ride services, respectively. The hotel industry, for example, has shown to be extremely vulnerable to the strategic disruption presented by sharing platforms like Airbnb [9]. It is envisioned that the proliferation of the sharing economy firms and platforms in the coming years will reach a degree where it will eventually become an inevitable and crucial part of the global economy [10].

It seems likely that the digital sharing economy will become an important domain of ICT application; it can therefore be analyzed with existing approaches to assess the sustainability of ICT applications. The relevance of digital sharing for sustainability is indicated by the following aspects:

- The new practices of the digital sharing economy, along with the rules and regulations that influence them, have implications for the prevailing patterns of consumption at a large scale. The affordable, accessible marketplace of sharing shifts consumption from an ownership habit to more access-based practices. This development has a considerable potential for saving natural resources (and the emissions and waste connected to their use) due to increased utilization of existing assets and the stimulation of resource-efficient alternatives (e.g., bike-sharing in cities can make the use of bikes more popular) on one side. On the other side, the efficiency gains can also increase the level of demand. Increasing demand due to efficiency gains is a systemic effect known as 'rebound effect' that has already been observed in other fields where ICT has increased efficiency [11,12].
- The sharing economy is claimed to have positive social effects. In addition to economic motivations, social motivations drive participation in the sharing economy. The act of sharing can connect people and promote social cohesion [13].
- Digital sharing is an enabler of bringing economy to the level of social practices whereby people become economic actors in their social bonds. Although this creates opportunities for empowerment, it has also generated debate on social inequality. The sharing economy has raised controversies about inequality—most of which vary depending on particular instances of sharing platforms—such as: entry barriers (in terms of dependency on holding an asset or having a skill to enter the platform-based labor market), labor conditions, wages, dependency on income and degree of satisfaction, and classification of workers (in terms of educational attainments and race hierarchies) and class-based/person-to-person discrimination [14].

Based on these first insights from literature, we consider it important to reflect on the potential implications of the digital sharing economy for sustainability.

Some authors have already started the academic debate about the relationship between the sharing economy and sustainability (e.g., [15–19]). Both utopian and dystopian views on the implications of the sharing economy for sustainability have been expressed. Heinrichs [15] introduces the sharing economy as a new approach that has the potential to contribute to sustainability and sustainable

development. By investigating the success factors of the sharing economy, Hasan and Birgach [18] call it a “sustainable economic model”. They reason that the emergence of consumers who are interested in sharing, in affordability, and in environmentally friendly options are key success factors for sharing business models; given that, they regard the sharing economy as a sustainable economic model. From a behavioral perspective, Hamari et al. [17] point out that participation in sharing does not necessarily support sustainability as long as it is not accompanied by positive attitudes that come into action towards sustainability in collaborative or shared consumption. Other scholars opine that the assumed transitional role of the sharing economy to sustainability is doubtful (e.g., [19]). From the viewpoint of Martin [19], the sharing economy has paradoxical implications for sustainability: On the one hand, it can potentially promote sustainable practices and patterns of consumption and production; on the other hand, it may reinforce the prevailing unsustainable economic paradigms through, e.g., creating unregulated markets. Martin [19] also puts forward the demand for investigating how the course of the sharing economy could be directed towards a transition to sustainability. In a similar vein, Demailly and Novel [16] call attention to “making the sharing economy sustainable”. They emphasize that achieving the economic and environmental benefits of the sharing economy depends on several conditions, including the presence of appropriate economic and regulatory frameworks and the degree to which users’ behaviors and individual motivations heed environmental considerations in their choices.

Owing to the relative novelty of the concept of sharing economy, it is not straightforward to adopt rigorous approaches in studying it. It is also not surprising that many aspects of digital sharing have not been thoroughly investigated yet. Nevertheless, the sharing economy’s impacts on sustainability should be studied prospectively as they may have important implications for the future of human life on the planet.

This article is a first attempt to conceptualizing the digital sharing economy as an ICT-enabled phenomenon and by analyzing it in the light of the existing discussions of ICT impacts on sustainability. Assessing the implications of ICT for sustainability has a long tradition [20]; our approach here is to treat the digital sharing economy as a use case of ICT (we are using the term ‘use case’ here with the meaning that has been established by the Global e-Sustainability Initiative (GeSI) [21]. In Section 2, we will first define the terms ‘sustainability’ and ‘digital sharing economy’. Section 3 connects the two spheres of discourse (sharing and sustainability) by interpreting the concept of the digital sharing economy in a sustainability context; Section 4 applies the “Life-cycle/Enabling/Structural impacts model” (‘LES model’ for short) to analyze this intersection. The LES typology proposed by Hilty and Aebischer [22] is an approach to conceptually structure the potential impacts of the digital transformation on sustainability. Sections 5 and 6 are devoted to further discussion and conclusion.

2. Basic Definitions

2.1. Sustainability

Sustainability, as we are using the term throughout this article, is the property to contribute to sustainable development. The most widely cited definition of ‘sustainable development’ was formulated by the World Commission on Environment and Development in 1986: “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs” [23].

This definition, also known as the ‘Brundtland definition’, has been paraphrased many times. Christen [24] points out that sustainable development “might best be conceptualized as an attempt to grant the right to a decent life to all living human beings without jeopardizing the opportunity to live decently in future.” The openness of the idea of a decent life leads to a basic normative question that cannot be avoided when discussing sustainability: “What has to be guaranteed or safeguarded for every person, no matter whether she lives at present or in the future?” ([24], p. 2). The UN Sustainable Development Goals (SDGs), adopted by 193 member states of the UN general assembly in 2015, can

be seen as the currently reachable political consensus on this question. They are summarized in the preamble with the words: “We are resolved to free the human race from the tyranny of poverty and want and to heal and secure our planet” ([25], p. 3).

We are aware of the variety of frameworks that are based on the so-called “three pillars” or “dimensions” of sustainability (namely the social, environmental and economic dimension), including the triple bottom line approach (People, Planet, Profit). We intentionally do not use this type of frameworks because they can imply an ontology in which economic systems seem to exist outside society, and society outside nature; two views that both contradict our ontological assumptions. In contrast, we regard the economic system as a part of human society and human society as a phenomenon that has become possible due to the biological processes on earth which have been reliably carrying it so far.

Social practices shape institutions—in a broad sense, as “the more enduring features of social life” ([26], p. 24), and as a special case, economic structures. We further assume that all human activities are interactions with the physical and biological environment because they are all based on metabolism, i.e., on the exchange of materials and energy with the biosphere [27,28]. The life-cycle effects, enabling effects, and structural effects (LES) model, proposed by Hilty and Aebischer [22], that has been developed to structure the impacts of ICT on sustainability is based on this view. We will use the LES model in Section 4 to address the implications of the digital sharing economy for sustainability. The rationale behind this perspective is described in more detail in [22].

2.2. Digital Sharing Economy

The contemporary sharing economy is enabled by ICT-based platforms, making sharing heavily dependent on ICT [29]. By providing a technological infrastructure for sharing, ICT has shaped new forms of social connections that can be upscaled to social relationships reliable enough to perform economic activities. The role of technology—including social networking platforms, big data, new algorithms, and cloud computing [30]—has led to presenting the sharing economy as a technological phenomenon [17] and to labeling it ‘digital matching economy’ [31] or ‘platform economy’ [30].

In addition to focusing on technological aspects, a number of studies refer to the peer-to-peer type of transaction/networking in the sharing economy (e.g., [17,32]); leading to the term ‘peer economy’ [33,34]. Although the striking growth and popularity of the sharing economy came to the fore due to its enabling individuals to perform economic activities in their peer networks and to make ‘purposeful’ social bonds, peers are not the only actors in sharing systems; business-to-peer (B2P), peer-to-business (P2B), and business-to-business (B2B) models can also feature. For example, in a B2P market, a company provides the platform and supplies the resource to be shared. Here, the platform provider, a ‘commercial’ sharing firm, is on one side of the transaction, as opposed to P2P models in which peers are service providers who ‘authorize’ access to and ‘share’ their owned resource.

We think of ‘sharing’ in the sense of sharable resources. This implies that using or consuming a resource can be recognized as a ‘service’ in a sharing system and receiving this service may involve either direct or indirect monetary compensation. That is, in general, two types of sharing services with regard to the economic value can be assumed: One that involves the flow of money (for-fee sharing) and one that involves only indirect monetary value obtained through not paying for the service received (not-for-fee sharing). Therefore, the digital sharing economy can include systems that are entirely based on non-monetary value flow such as time bank schemes. In not-for-fee sharing, services are either free or some form of compensation is expected or required (depending on the type of services and resources offered by a particular platform); this may include (in)formal reciprocity with skills, time, other resources and so forth. For example, time-banking—in which services are exchanged based on time as a currency—basically does not generate income and does not create employment. However, people participating in time-banking obtain indirect financial value through using their skills in units of time to help each other in reciprocity of the services they receive in their social bonds.

A literally comprehensive definition for the sharing economy that could embrace its common features should possibly describe the system, its activities and transactions, and the actors involved in it. Therefore, our proposed definition for the ‘digital sharing economy’ is as follows:

“A digital sharing economy is a resource allocation system, based on sharing practices, that is enabled by information and communication technology (ICT) and coordinated through participation of individuals and possibly commercial organizations (businesses) with the aim to provide temporary access to resources that involves either direct or indirect monetary value.”

Our definition overlaps with the common concept of collaborative consumption. However, there are forms of the digital sharing economy that are not considered collaborative consumption (but rather collaborative production), and there are forms of collaborative consumption (namely gifting and bartering that are excluded from the digital sharing economy by our definition. To clarify, our definition excludes bartering and gifting because they do not create a (potentially) lasting economic gain from the resource that is being exchanged or donated (any particular resource cannot be gifted more than once per peer; hence not a persistent value flow can be created). Gift or non-commodity economy is distinguished from other economic systems and has been studied in regard to the concepts of moral economy and political economy [35]. Moreover, when a good is donated or exchanged, it is withdrawn from the sharing domain (with the change of ownership) as it enters redistribution/reuse cycles. Although in some studies recirculation of goods is considered as sharing economy practices [7], we exclude them by definition. The sharing economy in our definition does not involve transfer of ownership, rather provides access. That is, in a sharing system, the utilization of a resource is increased only through facilitated and intensified access to it and not through multiple ownerships over its life cycle.

3. Links between Digital Sharing Economy and Sustainability

In this section, we explain our conceptual approach to the sustainability of digital sharing. Figure 1 illustrates the conceptual relation between the ICT-enabled sharing economy and sustainability as we defined the two concepts above. A refined analysis of this relation will take place in the following section.

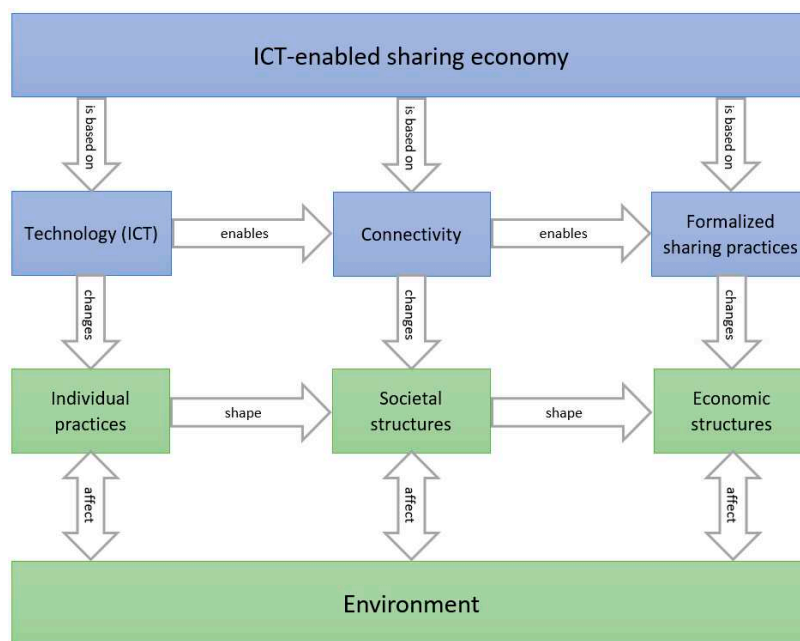


Figure 1. Conceptual relations between aspects of the Information and Communication Technology (ICT)-enabled sharing economy (blue) and aspects of sustainability (green).

ICT-enabled sharing platforms have changed *individual practices* in connecting, exchanging, and cooperating. Online platforms have established and scaled up peer-to-peer relationships to an unprecedented level [19], to a degree that can be perceived as a change in *societal structures*, which in turn has changed *economic structures* as an important special case. As technological providers, digital platforms endorse sharing practices [17] by coordinating the social, including economic, dynamics of sharing. They provide *connectivity* through which they enable structural changes by creating networked societies.

In fact, the digital sharing economy has *formalized sharing practices* that before were informally done among friends and within communal ties of smaller scopes. By enabling this formalization, digitalization has made sharing scalable to an unprecedented extent. In the digital sharing economy, actors, connections, transactions and other components of a sharing process are recorded and tracked and are thus to some extent transparent. In addition, platforms aggregate reviews and ranks that can be viewed as formalized substitutes of former face-to-face trust and reputation building processes required for a functioning sharing economy. Therefore, digital platforms can be viewed to have enabled and triggered the evolution of previously informal and non-scalable sharing activities into formalized, scalable socio-economic practices.

We would like to point out that the digital sharing economy, while formalizing sharing activities, still remains part of the informal sector in many of its instances, if not all. From a labor-market perspective, the digital sharing economy is not part of the formal economy, which is characterized by being “based on the employment of waged labor within a framework of rules and regulations, usually devised and implemented by the state, on working hours, minimum wages, health and safety at work, or the social security obligations of employers and employees” ([36], p. 502). Jobs in the formal economy, as opposed to jobs in the sharing economy, are secure and protected to some extent, with regular wages or salaries, and with workers’ (formal) contribution to public services through paying taxes on their incomes [36]. By contrast, the informal economy is defined to be “comprised of all forms of ‘informal employment’—that is, employment without labor or social protection— . . . including both self-employment . . . and wage employment in unprotected jobs” ([37], p. 2). Considering the ‘informality’ of taxation in the sharing economy, platform-based markets, such as Uber and Airbnb, are claimed to have allowed for and promoted tax avoidance/evasion [19,38]. While raising issues about labor condition [14,39] and taxation, the informality of the labor market created by the digital sharing economy has made it extremely easy to participate with lowest entry barriers; a feature that is not normally assumable with the formal sector.

The disruption brought about by the sharing economy moved economy back to the individual level and within and among social groups, whereby individuals become economic actors in the supply-and-demand dynamics of peer markets. Recalling our ontological assumption, the environment is influenced by human activities, that is, the way humans behave, communicate, produce, consume, and do commerce. As a consequence, positive or negative impacts of such activities retroact onto human life, often with a delay. For example, in the case of negative effects, excessive use of natural resources results in a deteriorated environment (e.g., [40,41]). As a special case, human actions resulting from the digital sharing economy and the resulting changes to production and consumption processes may lead to favorable or unfavorable environmental effects.

The life-cycle impacts, enabling impacts, and structural impacts (LES) model has been developed to structure impacts of ICT on sustainability and will be used in the following section.

4. LES for Sustainability of Digital Sharing

In the following, we will use the LES model (Figure 2) to frame the digital sharing economy as a use case of ICT. In particular, we will frame it as a use case in which information is partially substituted for tangible resources (which will be classified as process optimization on Level 2 of the LES model). This is a change in practices of production and consumption that is discussed for its potential to transform economic structures and social norms in the long term (Level 3 of the LES

model). Following the model, this structural transformation will then retroact on the general patterns of production and consumption (descending arrows from Level 3 to Level 2 of the model). For the details on the LES model refer to [22].

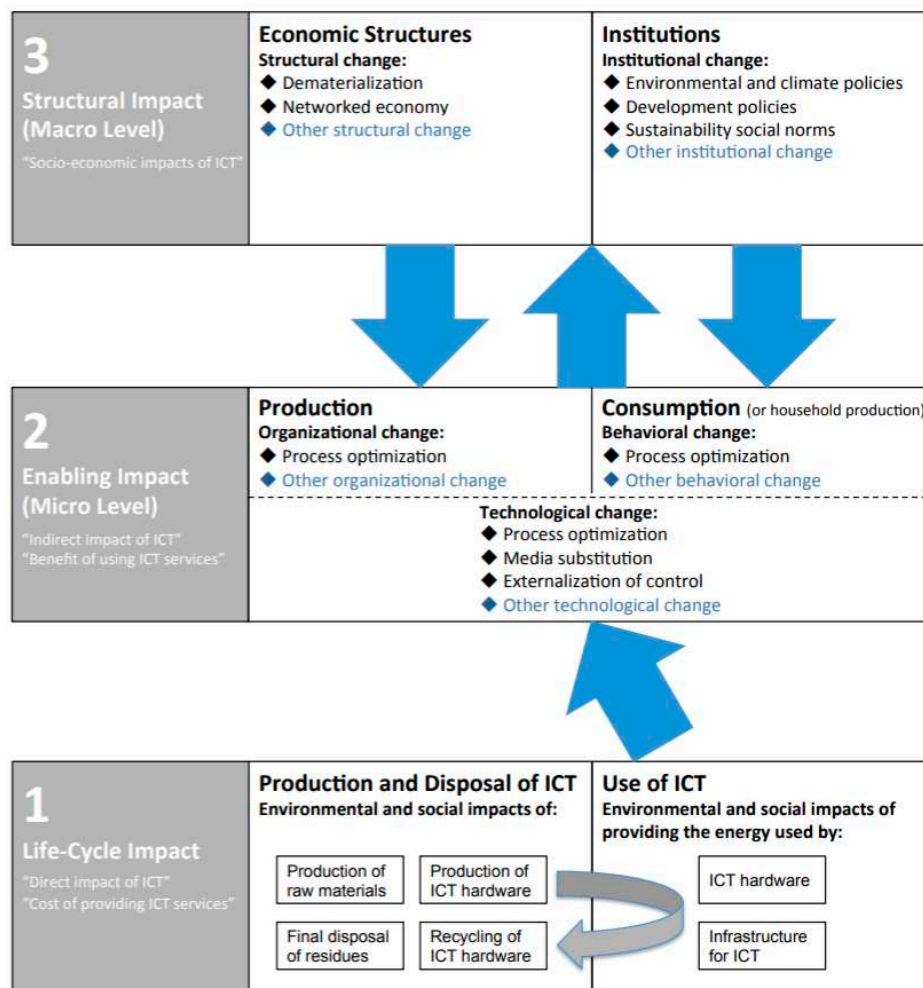


Figure 2. LES model: A conceptual framework for analyzing and assessing the Life cycle impacts, Enabling impacts, and Structural impacts (LES) of ICT (source: [22]).

An important characteristic of a sharing economy is the preference given to on-demand access to existing products over the production of new ones [42]. In the digital sharing economy, this is enabled by improving the information flow among the participants, which in the LES model is interpreted as process optimization (both in production and consumption), leading to a substitution of "pure" information for new tangible products. In other words, the availability of information that coordinates access to existing durable goods partially replaces the need for buying new goods. The increased level of real-time information generated, processed and distributed via online platforms may therefore reduce the need for new resource inputs into the 'sharing ecosystem'. This is accompanied by a change in the need for ownership: The final consumer of a service provided by some system of tangible goods (product system) does no longer have to own parts of this system. While this roughly describes what may be the most essential effect of the digital sharing economy, we will now systematically go through all three levels of LES from the bottom to the top.

4.1. Life-Cycle Impacts

Although we expect the most interesting impacts of the sharing economy to be found at levels 2 and 3 of the LES model, we have to consider the level-1 impact as well to be complete. Impacts that are undesirable from a sustainability perspective can arise from any stage of the life cycle of tangible/material resources, from their extraction throughout production, to consumption, and to post-consumption phases [40]. As an intangible/immaterial resource, information is different. But still, information needs some material substrate. Therefore, the life cycle of the material substrate for information, namely ICT hardware, has to be taken into account as well.

Level 1 of the LES model therefore addresses the sustainability impacts of production, use and disposal of ICT hardware. The sum of these impacts is also called “life-cycle impact” of ICT and is mainly based on the fact that all life cycle stages cause the exchange of energy and materials with the environment—and possibly also with people whose health can be affected. These impacts, if expressed per unit of information service, have already been dramatically reduced and can be expected to be further reduced by ongoing technological progress [43].

ICT hardware is not as clean as its image. Mining the materials and manufacturing the devices is done under high pressure on humans and nature [44]. Operating the hardware during its service life needs electricity, which is often generated from fossil fuels and in this case causing substantial CO₂ emissions. Scrapped ICT devices become hazardous waste, which can, if not treated properly, create high damage to human health, soil, and water [45]. In addition, labor conditions in the ICT industry [46] and in informal ICT end-of-life treatment are not sustainable [45,47–49].

Looking back into shorter history, the energy efficiency of ICT has doubled every 1.57 years; nevertheless, the overall energy used for ICT has increased because the demand for ICT has been growing even faster than the improvements in ICT energy efficiency [50].

Concerning the digital sharing economy, we can assume that the total life-cycle impact of the digital sharing platform is usually very small compared to the (positive or negative) impact of the resources being shared. For example, the smartphones and servers used to organize car sharing have a relatively small life-cycle impact compared to the life-cycle impact of a single car, which on average emits per 200–300 km driven as much CO₂ as a smartphone during its whole life cycle [51,52]. Furthermore, we only have to allocate a relatively small part of the smartphone’s life cycle impact to the purpose of participation in sharing platforms because the use of smartphone, as a multi-purpose device, is itself shared among many purposes and applications.

Studies comparing the life-cycle impacts of ICT on greenhouse gas emissions to the greenhouse gas abatement potential (due to enabling impacts) of the most relevant use cases have shown that the life-cycle impacts are usually smaller (e.g., [53,54]).

Nevertheless, there may be cases in which one would like to quantify the life-cycle impact of a digital sharing platform. In such cases, existing research on the impacts of ICT production: material resources [44,55,56]; labor conditions in ICT industry [46,57]; ICT energy consumption [50,52,58–60]; ICT end-of-life treatment under varying conditions [45,47–49]; and social impacts [61] can be consulted as a basis for sustainability assessment.

A caveat has to be made here with regard to the potential future use of distributed ledger (blockchain) technologies as infrastructures for digital service economies. As already observed with crypto-currencies, the algorithms used for security reasons can create an energy issue [62].

4.2. Enabling Impacts

Level 2 of the LES model considers what ICT is used for; it refers to the enabling impacts of ICT, that is, the (desirable or undesirable) impacts of actions that are enabled by the application of ICT in production or consumption processes. The enabling impacts of ICT can be categorized according to the effects of technological changes (process optimization, media substitution, externalization of control, and others) which are enabled by ICT application and which can bring processes of production and consumption closer to a theoretical optimum in terms of resource efficiency. Level 2 is the part

of the model where the most obvious effects of the digital sharing economy on sustainability, that is, increased access to resources and intensified shared use, can be described.

Optimization at the technical level (e.g., the possibility to unlock a door with a key sent to one's smartphone) leads to an optimization of production and consumption patterns. If we understand "production" in the wider sense of the term which includes the provision of services, all instances of the digital sharing economy which provide services can be viewed as new production patterns that are closer to a theoretical optimum (with regard to efficiency) than the traditional pattern. For example, ride sharing makes the *production of a ride from A to B* more efficient for the n participating passengers because only $1/n$ th of the infrastructure—i.e., the vehicle, the work of the driver and the energy (roughly)—is needed per passenger. In this sense, digital sharing platforms optimize production processes.

Digital sharing platforms can optimize consumption patterns as well. According to our definition, all instances of digital sharing provide temporary access to a resource. Accessing and using this resource is seen as an act of consumption (in the economic sense of the term) which, however, does not necessarily 'consume' (in the more general sense of the term) the resource if it is a durable good. For example, giving someone access to a room with a bed place will provide the guest with a service (the possibility of staying overnight), while the tangible goods involved usually survive for further use.

An optimization effect in consumption processes in the sharing economy reduces the need for new products and thus resources. The contributing role of digital sharing to a more sustainable consumption process is compelling to some extent as sharing slows down the flow of tangible resources by enabling an extended mode of utilizing them, just by sharing an intangible resource, that is, information.

The boundaries between production and consumption are being increasingly blurred in the context of the sharing economy [42]. While economics typically regards businesses as producers/suppliers of goods and providers of services, and private households (or their individual members) as consumers of these goods and services (or producers of goods and services for their own needs, what has been called household production [63,64], the sharing economy allows individuals to also take on the role of service providers and goods producers themselves. Although in extant management theory and practice, the ability of individuals to produce on their own is not counted as production [42], the digital sharing economy has enabled production at individual level and for small-scale businesses by provision of facilities (for individuals) and optimizing, in cases bypassing, the required organizational processes (for small businesses). An explicit example for production in the sharing economy could be platforms which offer space to individuals for shared use and for production purposes, such as shared spaces for food preparation [65] and work. In addition, Cohen and Munoz [65] classify group purchasing of renewable energy as "sustainable production" processes offered by sharing platforms. Group purchasing of renewable energy supports homeowners in converting to solar roofing and enables individuals to obtain localized renewable energy solutions at a discount over retail rates. The emergence of these "energy prosumers" decentralizes the energy provision via prosumer communities and can contribute to the sustainability of the electricity system [66].

Platforms that present three-dimensional (3D) printed goods are also categorized in the "sustainable production" platforms [65]. They provide access to printers for individuals and small businesses within a local community. 3D printing technology lowers manufacturing inputs and outputs through low-volume, customized, and high-value production processes at a low cost [67]. It reduces the manufacturing-related resource use and energy demand by only consuming the quantity of materials that will end up in final products without producing too much process-related waste. In addition to optimizing manufacturing of products, 3D printing contributes to saving energy and reduction in CO₂ emissions over the entire life cycle of its products and per unit of gross domestic product (GDP), and can be a potentially effective catalyst for environmental sustainability and sustainable development [67]. Combining this potential of 3D printing with what sharing platforms offer—i.e., "tak[ing] production out of the factory and into the city and show[ing] the people that they can be part of production again" ([65], p. 20)—can promise new forms of sustainable, resource-efficient, and optimized production in the sharing economy.

Research about the production optimization potential of the sharing economy is still ongoing. To date, studies in this area are insufficient to provide deeper insights. Investigating how digital sharing may contribute to sustainable manufacturing, to what extent and under which conditions it reduces the material and energy needs and wastefulness of production processes is needed. Further research may also analyze in greater detail to what extent collaborative consumption may lead to collaborative production and what this implies in terms of sustainability.

4.3. Structural Impacts

Level 3 of the LES model refers to changes in societal structures that result from enabling effects (Level 2) and persist over a long term. Structural changes alter the conditions for the patterns of production and consumption and vice versa. The difference between the levels 2 and 3 is that societal structures are described at a macro level using a language referring to aggregates of large numbers of entities and their emerging behavior, whereas patterns of production and consumption are described at a micro level, using a language describing individual entities, their decision-making and interactions.

4.3.1. Economic Structures

An important special case of societal structures are the economic structures, for example, the prevailing and accepted business models and existing distributions of power in the market. The disruptive nature of some types of the sharing economy (as described in Sections 1 and 3) has the potential to change these structures by challenging old monopolies and possibly establishing new ones.

The informal, peer-to-peer type of participation can create a “socially-connected economy” [3]. Disruption brought by the digital sharing economy can be perceived from this viewpoint: The sharing economy has enabled people to perform economic activities (from practices involving not even reciprocity to business transactions) in their everyday life independently of the formal sector. Before the advent of the sharing economy, businesses in the formal sector were the predominant product/service providers. Using sharing applications, which are easily accessible through smartphones, individuals can supply and obtain products and/or services in their peer network and are therefore not merely dependent on formal businesses.

An obvious structural change enabled by ICT infrastructures is therefore the transition to what has been called a “networked economy” since the early days of the Internet. “The fundamental unit of such an economy is not the corporation but the individual. Tasks are not assigned and controlled through a stable chain of management but rather are carried out autonomously by independent contractors” ([68], p. 14). In the context of today’s sharing economy, we see how this transition in economic structures (ways we do business) is also a transition in social relations. Thus, the border between the left and right part of Level 3 of the LES model can be seen as blurred. From a technological and economic perspective, sharing becomes viable by technology dropping the cost of communication [69] and enabling them to perform economic activities through a socially connected system. From a social perspective, social interaction and social cohesion in sharing [70] allow individuals (rather than corporations) to be the fundamental units of economy and to perform tasks with more autonomy.

In addition to social capital and social empowerment, the sharing economy creates economic growth [71]. The non-market type of P2P connections enabled by social sharing can provide a more efficient system for production, provision and exchange [72]. This associates sharing with productivity and a form of production that is supported and valued through mechanisms of social coordination [72]. We may classify such changes as structural impacts in the LES model, i.e., as changes in economic and institutional structures (institutions, in this sense, include anything intangible that shapes action, i.e., law, policies, social norms, and anything that can be regarded as the ‘rules of the game’).

Dematerialization is viewed as a special case of decoupling, an idea that lies at the core of sustainable development [22]. Dematerialization at the macro level is the decoupling of economic growth from resource use which means reducing the rate of use of (primary) resources per unit of GDP [40]. Although the sharing economy involves a substitution effect that occurs in replacing tangible

assets with increasing level of immaterial resource (information), the question whether, to what extent and under what conditions it will drive dematerialization has to be considered open. In terms of the LES model, the interdependence of Level 2 and Level 3 is complex; there is no simple way of deriving macro-level impacts from the enabling drivers at the micro level.

Obviously, there is still high dependency on material and physical assets in sharing systems. Sharing is inherently expected to balance the need for ‘new’ products. In fact, the case with the sharing economy is a shift of consumption from the ownership of new products towards the access to available, underused resources that may not necessarily represent dematerialization and may not eventually lead to a decoupling effect. To assess the dematerialization effect in specific case, the following two steps are necessary:

First, a comprehensive Life Cycle Assessment (LCA) of the two scenarios (the “traditional” way of providing the resource and the “new” way involving digital sharing) has to be done. The comparison of the results will reveal the size of the dematerialization effect. Although some types of the sharing economy such as shared work spaces seem to clearly contribute to dematerialization, this is not so clear if other practices change as well, e.g., how far people travel to their work in each scenario.

Second, rebound effects have to be considered. If any product or service becomes faster, cheaper or more convenient to access, the usual reaction of a market is an increase in demand, which may balance out the favorable effects of shared consumption within the same product/service system (direct rebound effect). It may also be the case that the time or money saved due to sharing is spent on other consumption which is less dematerialized (indirect rebound effect). The most important way in which rebound can occur in digital sharing is that the resource shared is consumed more (direct rebound due to lower cost, including time cost), so there will be more consumption at Level 2 of the LES model which can, in the long run, become structural at Level 3. In addition, is possible that the availability of information provided by the sharing platform stimulates demand for such real-time information and thus, via the increased demand for ICT infrastructure such as servers, communication bandwidth and end devices, has a rebound effect at Level 1. Only studies on a variety of specific instances of the sharing economy can reveal under what conditions digital sharing will be able contribute to dematerialized consumption.

4.3.2. Institutions

Individual practices are guided by institutions that provide some long-term stability while implementing societal structures. Important institutions in the context of sustainability are, for example, societal norms as well as environmental and development policies. Since sharing practices are originally based on deeply-rooted social norms and practices are transformed in the evolution of the digital sharing economy (as described in Sections 1 and 3), it becomes relevant to sustainability how social norms are changing in the process of digitalization.

Environmental and Climate Policies

As mentioned in Section 3, while influencing human life, the environment is itself influenced by human practices. Production and consumption processes and the way they are transformed by the digital sharing economy may lead to favorable or unfavorable environmental effects [73].

Environmental policies aim to address the problems that arise as humans continue to affect the environment. The digital sharing economy is (expected to be) associated with resource efficiency, sustainable consumption and waste reduction [74]. However, despite the success of some environmental and sustainability initiatives related to the sharing economy, it is not still clear whether the overall trend of sharing will appear to be following a sustainable pathway. From a policy perspective, the importance of defining business paradigms that support sustainable, collaborative consumption while considering the environment should not be neglected [74].

Technological improvements are not sufficient for eliminating negative environmental impacts [75]. Technological progress also plays its own part in creating environmental effects

and concerns. For example, telework can save commuter traffic, but telecommunication has also made possible long-distance private and business relationships which may induce a demand for additional transport [76]. Technology is in general capable of both diminishing and creating environmental issues (for a system dynamics model considering both positive and negative effects of ICT see [77–79]). Reducing environmental impacts calls for positive changes in human behavior too [74,75]. Individualistic behaviors have created increasing environmental imbalances [80]. However, human behavior still plays a significant role in solving environmental problems, and most environmental policies include and require considerations for shifts towards sustainable behavior [74].

These general insights can be illustrated for the case of the digital sharing economy using the example of car sharing. Although the environmental benefits of traditional car sharing are extensively accepted, understanding the environmental impacts of personal car sharing in P2P sharing models are still points of debate [81]. With regard to the questionability of the environmental contribution of well-used personal car sharing schemes in cities, three relevant arguments can be raised: (1) affordable vehicle sharing may increase the net vehicle miles/kilometers traveled (VMT/VKT) by increasing the rate of car usage, due to induced demand (as a result of reduced costs) [82]; (2) intensified shared use of a car degrades it faster, this may further lead to the demand for new resources and resource (car) replacement and the impending replacement cost [83]; and (3) affordable car sharing may cause reduction in the use of public transport [82,84].

With regard to faster degradation of shared assets, one provision could be, for example, to apply effective prices; that is, prices that sufficiently justify the degradation of sharing [83]. According to Weber [83], “this price includes any commissions charged by a sharing intermediary as well as transaction costs which may arise when realizing the gains from collaborative consumption” (p. 2). To alleviate the climate and environmental impacts resulting from the increasing rate of journeys in shared cars and the assumable lower interest in public transport, one way could be to enter environmentally-friendly vehicles into the shared mobility systems. For example, by shifting car sharing to hybrid and/or electric vehicle sharing, considerable reductions in energy consumption and CO₂ emissions can be achieved [85].

There are macro-level policies for shaping the sharing economy. Examples of large-scale policies are governmental strategies at city level and strategies coordinating smart, sharing cities in multiple countries. Examples of these are: Seoul (the world’s first Sharing City) and the European Union Sharing Cities, consisting of Lisbon, London, Milan, Bordeaux, Burgas and Warsaw. The comprehensive approaches of such governmental strategies include the development of adapting regulations and provision of incentives for the expansion of the sharing economy [15]. According to its publicized vision, the EU’s Sharing Cities project aims to improve the living environment while reducing energy costs through managing city data and city infrastructures, and through sharing practices, solutions, results and experiences [86]. Many positive contributions can be attributed to such policies, both in theory and practice, as they remarkably improve the efficiency of resource allocation and services for citizens.

Development Policies

As a technology- and particularly Internet-driven phenomenon, the sharing economy can contribute to development through three main mechanisms: inclusion, efficiency and innovation [87]. Inclusion means including the transactions and parties that would normally be excluded without the presence of sharing platforms; i.e., transactions that were expensive or hard-to-coordinate before and parties that could not otherwise take on the role of service/goods providers. Low-cost digital technology has improved efficiency by making it possible to carry out transactions more quickly, cheaply and conveniently. Innovations are generated when sharing business models allow the offering of new services, while reducing the transaction and marginal costs to (almost) zero.

Although ICT has mainly been known as an enabler of development [88–91], its negative implications on development have also been studied; e.g., the digital divide and unequal access [92],

the urban-rural divide [93], and unequal digital literacy [87], all of which can be applicable to the digital sharing economy as well.

There also exist arguments with regard to the welfare, employment and income aspects of the development in the context of the sharing economy. Some authors believe that the sharing economy has created a positive transformation in the market, moving towards welfare enhancement [94]. Other authors claim that it acts in favor of those who already have assets to share and that it excludes those at the bottom of the income distribution [14]. Evidently, the sharing economy has been able to promote individual economic empowerment [19]; nevertheless, the advantages for workers may mean they end up having trade-offs with the enjoyment of flexibility and having a supplemental income against job insecurity and lack of employment protection [87]. With regard to underpayment and low wages, the sharing economy has been labeled as the “share-the-scrap economy” where most of the profits will go to the platform owners and the scraps go to the workers [94].

In addition to individuals, firms are the other actors in economic growth. The Internet promotes economic growth through intensifying competition [87] among sharing economy firms. Although it is claimed that high competition enhances consumer welfare [94], competition in the sharing economy can come with three major issues: inequality in the rate of adoption, inequality caused by disruption, and the creation of Internet monopolies [87]. The rate of digital sharing adoption is not equal among and across various sectors in various countries; according to the World Bank report [87], large, fast-growing, skill-intensive, and urban firms take advantage of the digital technologies more. Furthermore, the economics of digital sharing tend to create and favor Internet monopolies, as some platforms dominate the market. Despite these issues, sharing markets, platforms and Internet-based business models have created a dynamic environment from which firms can benefit significantly. Here, policies should ensure that sharing companies can compete on equal terms and that the economic performance of sharing firms of different sizes in different countries can be supported so as to enable them to contribute to national economies [87].

Sustainability and Social Norms

Social norms are “shared understandings about actions that are obligatory, permitted, or forbidden” ([95], p. 143) that may remain informal or become explicit formal rules. Social norms are viewed as a means of promoting sustainable behavior, and many interventions that encourage sustainable and environmentally friendly behavior are linked to certain established sustainability social norms [96]. In a networked society, efficient communication allows for social norms to evolve faster [22], as is the case with the digital sharing economy. Therefore, socially connected sharing systems have a potential to foster the development of social norms in the direction of social awareness of environmental sustainability.

5. Discussion

By applying the LES model to the concept of the digital sharing economy, we have identified the core issues that have to be taken into account when assessing the potential contribution of a given instance of the digital sharing economy to sustainability. We will summarize them in the form of questions, grouped by the levels of the LES model.

At Level 1, it is necessary to keep the sustainability impacts of the digital technology life cycle in view. In particular, if future sharing platforms are based on blockchain technology, it will be necessary to explore whether the energy consumption of the blockchain is worth the expected contribution to the reduction on energy use or greenhouse gas emissions at higher levels.

At Level 2, the enabling effects of digital sharing for the various actors in production and consumption processes should be investigated. In particular, the effects of sharing on sustainability can be assessed by answering the following questions:

- To what extent is the sustainability impact of the *material assets and the energy used* over their life cycle, calculated per service unit (functional unit) provided, smaller than in the non-sharing pattern?
- Is the *person providing the service* in a social position that is better or worse than before (e.g., regarding access to markets, participation in cultural life, labor conditions, opportunities for self-development, etc.)?
- Is the *person receiving the service* in a social position that is better or worse than before (e.g., regarding access to resources, participation in cultural life, opportunities for self-development, etc.)?

At Level 3, the expected long-term structural changes resulting from the enabling impacts should be reflected with regard to their relevance for sustainability by raising the following questions:

- To what extent is the material and energy saving impact expected to be counterbalanced by *rebound effects*, so that the overall dematerializing effect on the economy is smaller than it could be or even negative?
- From a *consumer perspective*, to what extent is the expected change increasing the opportunities for everyone to be part of a system of fair distribution?
- From a *provider perspective*, to what extent is the expected change increasing the opportunities for everyone to participate in a given market in the long run (low entry barriers, fair competition)?
- Can the established sharing practices be expected to support the development of social norms, institutions and policies need to achieve sustainable development?

We are adding three overarching questions that may be read as guiding principles for a sustainable sharing economy:

- Will the recognition of the value of limited material resources be increasing or decreasing in the long run by digital sharing practices?
- Is the development of the sharing economy increasing or decreasing the opportunities for all people to have decent work, be it in the formal or in the informal sector?
- Will there be progress in establishing norms of intergenerational justice, in particular the conservation of natural resources?

Further research may apply our framework in detail to outstanding instances of the digital sharing economy.

6. Conclusions

The sharing economy is often viewed as, or expected to be, an agent of change helping to overcome the currently unsustainable consumption patterns. Sharing is becoming more and more popular among people as a possible substitute for purchase and ownership. In recent years, there has been rapid growth in participation in the sharing economy and use of digital platforms by individuals and companies in various sectors. ICT-enabled platforms act as mediators to reduce the transaction costs between providers who offer a good or service and those who intend to obtain it. Owing to its affordability, accessibility, convenience, ease-of-use, and possible enjoyment, digital sharing is being increasingly practiced by people, particularly in peer networks; businesses have also appeared willing to operate in the digital sharing market.

The increased level of real-time and real-place information generated and distributed via online platforms enables intensified access to existing resources and, as a consequence, induces an increase of their average utilization. This is normally expected to decrease, or at least balance, the need for new resource inputs to consumption ecosystems. In so doing, the sharing economy would be viewed as a potential stimulus to reduce the ecological footprint of consumption and as an effective approach to sustainability and sustainable development. However, sustainability implications of sharing may go beyond such simplified assumptions. Further reflections can reveal broader scenarios.

In the present article, we applied the LES model to analyze the sustainability of the digital sharing economy as a use case of ICT. Referring to the Level 1 of LES, the direct impacts of digital sharing are small compared to the direct (favorable or unfavorable) impacts of a resource being shared as well as the direct impact of the technological infrastructure. As long as blockchain technology is not used, it can be expected that digital sharing will provide an energy-saving potential while outweighing the life-cycle impacts of running ICT. If blockchain technology is applied to sharing platforms, it should be explored whether the energy consumption of the blockchain is worth the expected savings.

The most important enabling impacts (Level 2) of the sharing economy occur as changes with patterns of production and consumption. From a resource-efficiency perspective, the optimization effect in shared consumption reduces the need for new products and resources. The contribution of the sharing economy to more sustainable consumption patterns can be compelling, as sharing eases off the flow of material resources by enabling their shared use—which itself is enabled by sharing an immaterial type of resource, namely information. Nevertheless, the extent of the sustainability impacts of shared use—compared to non-sharing patterns—should be investigated as well. From a sustainable development viewpoint, it is important to see whether digital sharing participants, particularly providers and consumers in peer networks, would attain a better social position, in terms of e.g., equal access to markets, participation in cultural life, improving labor conditions and opportunities for self- and social development.

Enabling effects, if prolonged, lead to lasting structural changes at macro level (Level 3). With respect to material and energy saving benefits obtained from sharing systems, it should be reflected whether and to what extent they may be counterbalanced by rebound effects, and whether the overall dematerializing effect on the economy is large enough, if not negative. From consumer/provider perspectives, prominent considerations would be towards creating and improving equal opportunities for everyone in sharing markets so as to promote fair distribution/competition for every (peer) consumer and (peer) provider.

Last but not least, the implications of the digital sharing economy for the development of social norms in the course of enhancing awareness towards a transition to sustainable development is of great significance; here, institutions and respective policies can further advance the progress.

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